LOGGING RESIDUES ON SAW LOG OPERATIONS, IDAHO AND MONTANA

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USDA Forest Service
Research Paper INT-77, 1970

INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION
Ogden, Utah 84401

COVER PHOTO

A large rot column. Several exploratory cuts (and an unusually lengthy longbutt) were needed here to locate enough sound wood for log making.

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THE AUTHORS

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ROBERT E. GREEN is a statistician in Region 4, U.S. Forest Service, headquarters in Ogden, Utah. At the time of this study, he was employed as a mathematician by the Intermountain Forest and Range Experiment Station, during which time he served as crew chief of the field crew on this study and developed the original computer programs for data compilation.

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* Note: See Terminology for definitions of many of the terms used in this paper.

TABLES

ABSTRACT

Reports results of a survey made of logging operations to estimate the volume of logging residues in relation to the volume of saw logs harvested in Idaho and Montana. Results show: conversion factors that can be applied to product volume to estimate total removals from inventory; residue volume as a percentage of saw log volume; the relative importance of felling and skidding as causes of residues; and the numbers of trees removed from growing stock inventory by logging. Survey methods and reliability of data are discussed.

INTRODUCTION

The volume of timber cut or killed during logging operations and left in the woods represents a reduction in the inventory volume available for future management and harvesting. Consequently, the volume of unused timber should be taken into consideration if differences between successive inventories are to be more fully understood. Estimates of the amount of logging residue potentially marketable as chips are of interest also.

In 1965, Forest Survey at the Intermountain Forest and Range Experiment Station conducted a survey of logging residues in Idaho and Montana. Logging residue surveys yield various types of information,[1] but only data considered to be sufficiently reliable for purposes of this report were used here. Information not included in the present paper may be combined with data from future residue surveys of other areas to provide adequate reliability for further analyses. Since 1965, Forest Survey has surveyed logging residues in Arizona, New Mexico, Colorado, Utah, Wyoming, and in South Dakota west of the 103d meridian. If present plans are adhered to, residues will be resurveyed periodically in all Mountain States.

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[1]Conversion factors to be applied to product volumes for estimates of total volumes removed from inventory in commercial logging; average conversion factors used to express product volume in several units of measure (cubic feet, International 1/4-inch rule, and Scribner log rule); the diameter distribution of trees removed from inventory by logging; the proportion of timber products harvested from growing stock trees compared to that of products from non-growing stock trees; cull and breakage losses by species; the relative importance of felling and skidding as causes of residues; and the proportion of logging residue volume made up of pieces of various size classes.

This report includes statistics for Idaho and Montana combined, for each of these States individually, and for northern Idaho-western Montana.[2] Statistics for other breakdowns are not shown because they would not be generally useful or because estimates could be unreliable. The northern Idaho-western Montana combination is included because data are sufficient for reliability. Moreover, the area is homogenous in many respects and frequently is considered to be an economic unit in resource analyses.

REMOVAL ESTIMATES

Expansion factors are computed to permit calculation of the inventory that remains following commercial logging operations. To adjust the inventory, removals (volume of products plus residues from felling and skidding) must be subtracted from the pre-logging inventory. However, the removal volume should omit material that was not included in the inventory, i.e., the portions of tree stems overutilized by inventory standards. Such material can come from cutting below the minimum stump height (1 foot by Forest Survey standards) or from harvesting product volume beyond specified top diameters. It also can come from harvesting saw logs from growing stock trees of less than the sawtimber size specified for inventory or by cutting roundwood products from cull trees.

Overutilized material (by Forest Survey standards) was excluded from the removal volume when the conversion factors shown in table 1 were developed. How-

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[2]Northern Idaho includes the following counties: Benewah, Bonner, Boundary, Clearwater, Idaho (north of the Salmon River), Kootenai, Latah, Lewis, Nez Perce, and Shoshone. Western Montana, that part of the State west of the Continental Divide, includes all of or portions of the following counties: Deerlodge, Flathead, Granite, Lake, Lewis and Clark, Lincoln, Mineral, Missoula, Powell, Ravalli, Sanders, and Silver Bow.

Table 1.--*Conversion factors to estimate total net removals from inventory, Idaho and Montana*

Unit of measurement and minimum top diameter	Idaho	Montana	Northern Idaho western Montana	Idaho-Montana
Cubic foot 4 inches	1.123	1.160	1.146	1.140
Board foot[1] Variable	1.054	1.067	1.064	1.060
Board foot[1] 7 inches	1.058	1.056	1.062	1.057

[1]International 1/4-inch log rule.

ever, the overutilized volume normally is part of the reported product volume to which these factors will be applied.

Therefore:

$$\text{conversion factor} = \frac{\text{removal volume}}{\text{product volume}}, \text{ which is}$$

equivalent to

$$\frac{\text{net product volume (excluding overutilization)} + \text{residue volume}}{\text{product volume (including overutilization)}}$$

In both Idaho and Montana, the net volume of timber removed from growing stock inventory averages 1.14 times the cubic-foot volume of saw logs harvested (table 1). The removal rate is somewhat lower in Idaho (1.12 times the saw log volume) and higher in Montana (1.16 times the saw log volume).

Factors for estimating removals from sawtimber[3] in inventory are somewhat smaller numerically than the factors used for estimating removals from growing stock. Factors derived for board-foot measurements to the minimum variable top standards used by Forest Survey (see *Sawtimber volume* in Terminology) are not much different from those derived for the minimum fixed top of 7 inches. By both top diameter standards, conversion factors used to estimate removals in Idaho and Montana combined amount to 106 percent of saw log volume; the proportion is slightly less for Idaho than for Montana.

Correction factors are numerically less for board-foot measure than for cubic-foot measure because considerable material scaled as net cubic-foot residue is not included in the net board-foot scale. Such material consists of (1) the upper stem portion beyond the minimum top diameter for board-foot measure, (2) the volume in destroyed growing stock trees of less than sawtimber size, and (3) portions of sound trees that are cull (because of crook) for saw logs.

LOGGING RESIDUES AND PRODUCT VOLUME

The net volume of logging residues represents underutilization by one standard or another. By Forest Survey's cubic-foot standards, residues include all unused net volume between a 1-foot stump and a 4-inch minimum top diameter inside bark (d.i.b.). By board-foot standards, net residue volume consists of unused material in sawtimber trees from a 1-foot stump to either the variable or the fixed top diameters. Merchantable logs missed in skidding are included in sawtimber residues.

The net volume of logging residues from harvesting a given volume of saw logs can be estimated by the use of table 2. For example, residues from the reported

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[3]Board-foot volumes used in this report are International 1/4-inch log rule volumes.

Table 2.--*Net volume of logging residues from saw log operations as a percent of net product volume, Idaho and Montana*

Unit of measurement and minimum top diameter	Idaho	Montana	Northern Idaho-western Montana	Idaho-Montana
Cubic foot 4 inches	12.27	16.26	14.75	14.09
Board foot[1] Variable	6.16	8.22	7.32	7.07
Board foot[1] 7 inches	6.48	7.44	7.07	6.90

[1]International 1/4-inch rule.

1966 harvest of 249,414 MCF of saw logs from growing stock in Idaho are estimated to be:

249,414 X 0.1227 = 30.6 MMCF

The largest part of residue volume results from felling. Most of this is material from trees from which saw logs have been cut. Skidding losses are relatively minor and, as shown by the following tabulation, amount to less than 7 percent of cubic-foot residue volume in Idaho and Montana combined.

	Felling				
	Product trees	*Other trees*	*All trees*	*Skidding*	*Total*
	- - - - - - -	*Percent*	- - - - - - -		
Idaho	76.63	18.19	94.82	5.18	100.00
Montana	86.16	6.05	92.21	7.79	100.00
Northern Idaho, western Montana	83.12	10.37	93.49	6.51	100.00
Idaho, Montana	81.63	11.82	93.45	6.55	100.00

It should be pointed out that residue volumes derived by the use of factors in table 2 are not totally available for chipping. A more detailed and intensive survey would be necessary to assess residue characteristics and to determine what portion of these residues could be used under prevailing market conditions.

DIAMETER CLASS REMOVALS

Information on the number of growing stock trees harvested or destroyed[4] in each diameter class is essential for derivations of diameter class cutting rates used in most stand-table projections of growth and inventory. Reliable data of this kind usually are difficult to obtain. However, logging residue surveys provide means for estimating the distribution of trees removed per unit volume of saw logs harvested.

Table 3 shows the total number of growing stock trees (product trees and others), removed per 1 MCF of product volume in Idaho and Montana. These figures can be applied to a given volume of saw log harvest to estimate trees removed in each diameter class. In turn, this estimate can be related to an inventory stand table in order to compute cutting rates.

SURVEY METHODS AND RELIABILITY OF ESTIMATES

A basic need in the logging residue surveys was to develop factors that could be applied to a reported volume of saw log harvest to estimate the resulting volume of logging residues. Estimates of residue volume are based on product volume rather than acreage logged because such information usually is more reliable and available (at least to Forest Survey) than are estimates of area cutover. The survey design

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[4]Either occurrence removes the trees from inventory.

Table 3.--*Growing stock trees removed from inventory in saw log operations per 1 thousand cubic feet of net product volume, Idaho and Montana*

Class (inches)	Idaho	Montana	Northern Idaho-western Montana	Idaho-Montana
	Number of trees			
2	6.0522	8.9259	8.4669	7.3587
4	2.8277	6.1291	4.5296	4.3287
6	3.0261	3.0348	3.0314	3.0301
8	1.1906	2.9158	1.5679	1.9749
10	.9426	4.7010	2.0557	2.6513
12	1.0418	4.3439	2.2648	2.5431
14	1.2402	4.1654	2.5436	2.5701
16	1.2402	2.6778	2.1951	1.8938
18	1.5875	2.2612	2.2300	1.8938
20	1.0914	1.1901	1.3937	1.1363
22	.6945	.5951	.6969	.6493
24	.7441	.2380	.5226	.5140
26	.5457	.2975	.4530	.4329
28	.3969	.1190	.2787	.2705
30+	1.6371	1.4281	1.4983	1.5421
All classes	24.2586	43.0227	33.7282	32.7896

prescribed three basic types of measurements of growing stock trees on active logging operations to meet this objective:

1. Net volume of saw logs harvested from *product* trees measured on a logging operation;

2. Net volume of residues from the *same* trees;

3. Net volume of residues from *other* trees cut or destroyed in the process of felling and skidding product trees.

All three sets of measurements were used to determine the residue volume as a percent of saw log volume. Scaling was done in detail to permit estimates of gross and net cubic-foot volumes for all measured growing stock trees, and to provide gross and net board-foot volumes to fixed and variable tops for measured sawtimber trees. Species, diameter breast height (d.b.h.), total height, overutilization (by Forest Survey standards), and cause of residue (felling or skidding) were recorded.

The number of basic sample units used in the survey corresponded to the number of logging operations on which measurements were taken. Before starting fieldwork in a State, an estimate was made of the number of sample units needed to assure a standard error of total residue volume of not more than ±20 percent to meet Forest Survey objectives. For the survey reported here, 41 sample units--18 in Idaho and 23 in Montana--were drawn from a list of known active logging operations in the two States. These were drawn at random from strata defined by geographic subunits, land ownership, and operator size class. Four subunits were used--northern Idaho, southern Idaho, western Montana, and eastern Montana. Two ownership classes were used--National Forest and other owners. Operator size class corresponded to

the production class of the sawmill for which the logging was being done. Two size classes were used--small (less than 10 MMBF per year) and large (10 MMBF or more per year).

Enough trees were measured on each sample unit to provide a product volume of between 4 to 10 MBF per sample unit. On the basis of previous survey experience, guides were developed so that field crews could estimate the number of trees to be measured to meet volume objectives. The number of trees varied with the range in average tree size, timber type, and stand age (young or old growth). From 10 to 30 trees were recommended for each sample. Actually, 597 product trees were used, an average of nearly 15 per sample unit. The net product volume scaled was 41,214 cubic feet (equivalent to nearly 258,000 board feet), an average of 6.3 MBF per sample unit.

Trees felled for products were measured in place to determine both product and residue volumes. Residue volume from other trees destroyed or cut when product trees were felled also was measured. Skidding damage to trees along skid trails was determined after logs reached a landing, except in those cases where crews had been on hand to witness damage as it occurred.

In clear-cut operations (usually in lodgepole pine stands), where there was difficulty in relating felling and skidding damage to individual product trees, a slightly different procedure was used. In such cases, product trees were those whose stumps were within a circular plot. All product trees on the plot were measured, and felling and skidding damage assessed within plot boundaries after skidding.

Data compilation was accomplished by means of a set of computer programs developed especially for these studies. The output included standard errors of the ratios for residue volumes. For example, table 4 indicates that the standard error of the cubic-foot ratio in Idaho is ±10.5 percent and in Montana, ±13.7 percent.

Table 4.--*Standard errors of ratios for logging residue volumes by net cubic- and board-foot*[1] *measures, Idaho and Montana*

Unit of measurement and minimum top diameter	Area[2]			
	Idaho (18)	Montana (23)	Northern Idaho-western Montana (32)	Idaho-Montana (41)
	Percent			
Cubic foot 4 inches	10.512	13.713	10.061	9.254
Board foot Variable	16.126	17.869	13.960	12.622
Board foot 7 inches	15.353	19.688	14.084	12.517

[1]International 1/4-inch log rule.

[2]Number of logging operations sampled in parentheses.

Caution is recommended if estimates shown in this report are to be applied to any subdivisions of Idaho, Montana, or of the northern Idaho-western Montana area. The amount of residue per unit product can vary widely from one area to another due to several interrelated factors. Among these are: stand conditions (size and soundness of trees, species, stocking, etc.); markets for various species; size and quality of timber; and logging costs and techniques as determined by accessibility, terrain, etc.

TERMINOLOGY

Cull trees.--Live trees of commercial species that will not now or in the future qualify as sawtimber trees because of dimensions, form, rot, or damage. Also includes all live trees of noncommercial species.

Cull volume.--Portions of a tree that are unusable for industrial wood products because of rot, form, or other defect.

Diameter classes.--A classification of trees based on diameter breast height (d.b.h.) outside bark. Two-inch diameter classes used by Forest Survey are identified by the diameter at the approximate midpoint of each class. For example, the 2-inch class includes trees 1.0 to 2.9 inches d.b.h.

Growing stock trees.--Live trees of commercial species, except those that are cull because of form, rot, or other defect.

Growing stock volume.--Net volume in cubic feet of growing stock trees 5.0 inches d.b.h. and over from a 1-foot stump to a minimum 4.0-inch top diameter inside bark (d.i.b.) of the central stem or to the point where the central stem breaks into the limbs.

Logging residues.--The unused portions of trees cut or killed by logging.

Net volume.--Gross volume less deductions for rot, sweep, or other defects affecting use for timber products.

Poletimber trees.--Growing stock trees likely to grow into merchantable sawtimber trees. They must not show evidence of rot in the main stem nor have serious damage, crook, or stagnation. Softwoods must be from 5.0 to 8.9 inches d.b.h. and hardwoods from 5.0 to 10.9 inches d.b.h.

Sawtimber trees.--Growing stock trees containing at least a 12-foot saw log and not more than two-thirds of the gross board-foot volume in cull material. Softwoods must be at least 9.0 inches d.b.h. and hardwoods at least 11.0 inches d.b.h.

Sawtimber volume.--Net volume (in board feet International 1/4-inch rule) of sawtimber trees between a 1-foot stump and a specified merchantable top--fixed or variable. A fixed top is 7 inches in diameter inside bark. A variable top varies with d.b.h. as follows:

Range in d.b.h. *Inches*	*Top d.i.b.* *Inches*
9.0 - 10.9	5
11.0 - 14.9	6
15.0 - 18.9	7
19.0 - 20.9	8
21.0 - 24.9	9
25.0+	10

Headquarters for the Intermountain Forest and Range Experiment Station are in Ogden, Utah. Field Research Work Units are maintained in:

Boise, Idaho
Bozeman, Montana (in cooperation with Montana State University)
Logan, Utah (in cooperation with Utah State University)
Missoula, Montana (in cooperation with University of Montana)
Moscow, Idaho (in cooperation with the University of Idaho)
Provo, Utah (in cooperation with Brigham Young University)